Space Weather Technical Forecast

Issued on Saturday, 11 February 2023 at 13:09 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: M-flares (R1/R2 Radio Blackouts) expected.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours. The largest event was a M2.3 flare at 11/0808 UTC surprisingly from AR3208, which is currently close to the west limb, this region will rotate off the disc in the next day or so. However, other regions have been sources for M-class flare over the past 24 hours, especially the large and magnetically complex regions, such as AR3213, which is now showing signs of simplification and has lost its delta spot. However, this region does maintain some magnetic complexity within its intermediate spots. AR3217 (Ekc/Beta-Gamma-Delta) is the other complex sunspot region, although it has been lacking in flares recently, continues to show some growth in the penumbral area of its leader spot, along with increased complexity, and contains a delta spot. There are currently eleven sunspot regions on the visible disc, with one new and unnumbered region in the southeast quadrant, although all other regions appear to be generally small, simple and relatively stable.

A CME was observed leaving the southwest quadrant of the Sun due to a filament eruption. This has been assessed as likely missing Earth, but with a glancing interaction possible late on the 14th or 15th (days 4 or 5). A couple of other CMEs occurred, however these are off the Earth-Sun line.

Solar Wind / Geomagnetic Activity: Solar winds continued to be slightly elevated or elevated, perhaps due to weak glancing CME influences. Observed speeds at L1 ranged between 480-550 km/s. The density was generally around average or slightly above, but fell below average between 10/1200 UTC and 10/1930 UTC. Total IMF strength, Bt, was mainly weak, below 8nT, with the north-south component variable between -5nT and +3 nT. Phi angle was initially negative (towards the Sun), then became rather erratic from 10/1630 UTC, between negative and positive. Geomagnetic activity was Quiet to Unsettled (Kp 2-3), but with an Active interval (Kp 4) between 10/2100-11/0000 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at Background. The high energy electron flux (greater than 2MeV) measured by GOES-16 was mainly Moderate, peaking at 982pfu at 11/0100 UTC. The associated 24-hour electron fluence was below Active reaching 2.46e7 integrated pfu at 11/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity expected with further M-class flares expected and a slight chance of X-class flares. The main risk is from AR3217 and AR3213.

Solar Wind / Geomagnetic Activity: CMEs which left the Sun on the 7th and 10th, while forecast to miss the Earth, give a low chance of glancing interactions on days 1 and 4 (11th and

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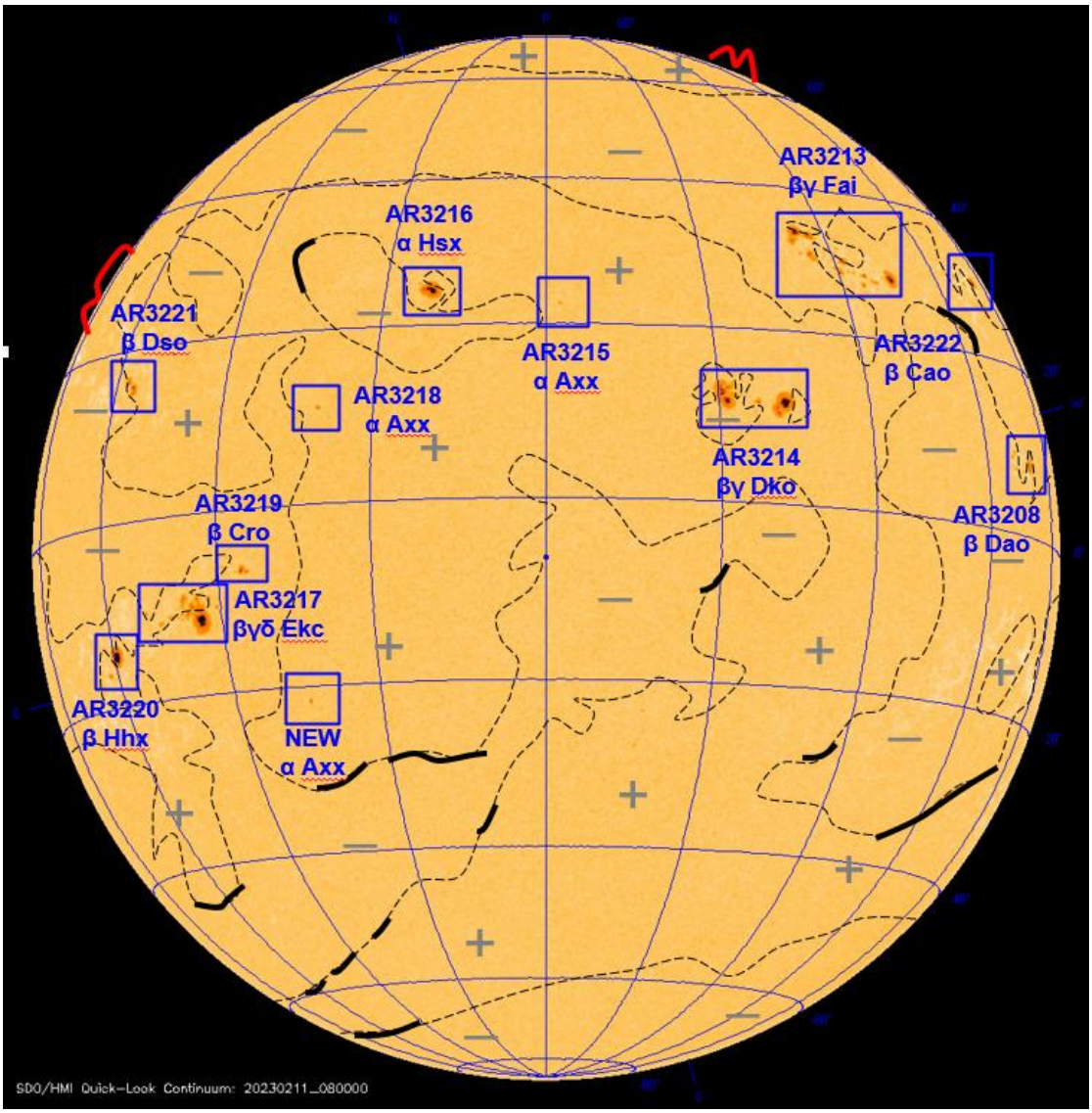
14th). Otherwise current slightly elevated solar winds are expected to erratically ease, with no other significant enhancements expected. Geomagnetic activity is expected to be mostly Quiet to Unsettled, with a decreasing chance of Active intervals. Any CME glance, however, has the potential to bring a more persistent Unsettled to Active spell, and a very slight chance of G1 Minor Storms day 1 and 4 (11th and 15th).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at background levels, but with a slight chance of rising in response to any significant flares. High energy (greater than 2 MeV) electron flux is expected to be at Background to Moderate levels, with an overall declining trend. The associated 24 hour fluence is expected to remain below the Active threshold (1e8 integrated pfu).

Figure 1. Solar Analysis Valid 11/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are a couple of CMEs which are expected the largely miss Earth, but have a chance of giving some peripheral interactions. The first is from a C-flare of AR3213 on the 7th, and is expected to pass above Earth's orbit on day 1 (11th). The second is from a filament lift off in the southwest disc on the 10th. This produced a wide, but slow CME, and is likely to miss Earth, passing ahead and to the south of it late on day 4 or day 5 (14th or 15th). However, glancing impacts are again possible.

There are no coronal hole features identifiable on the Earth-facing Sun, with current elevated winds expected to gradually but erratically ease. Enlil is giving good guidance for expected background winds. Geomagnetic activity is expected to be mostly Quiet to Unsettled, with a decreasing chance of Active intervals. Any CME glance, however, has the potential to bring a more persistent Unsettled to Active spell, and a very slight chance of G1 Minor Storms day 1 and 4 (11th and 15th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	1	1	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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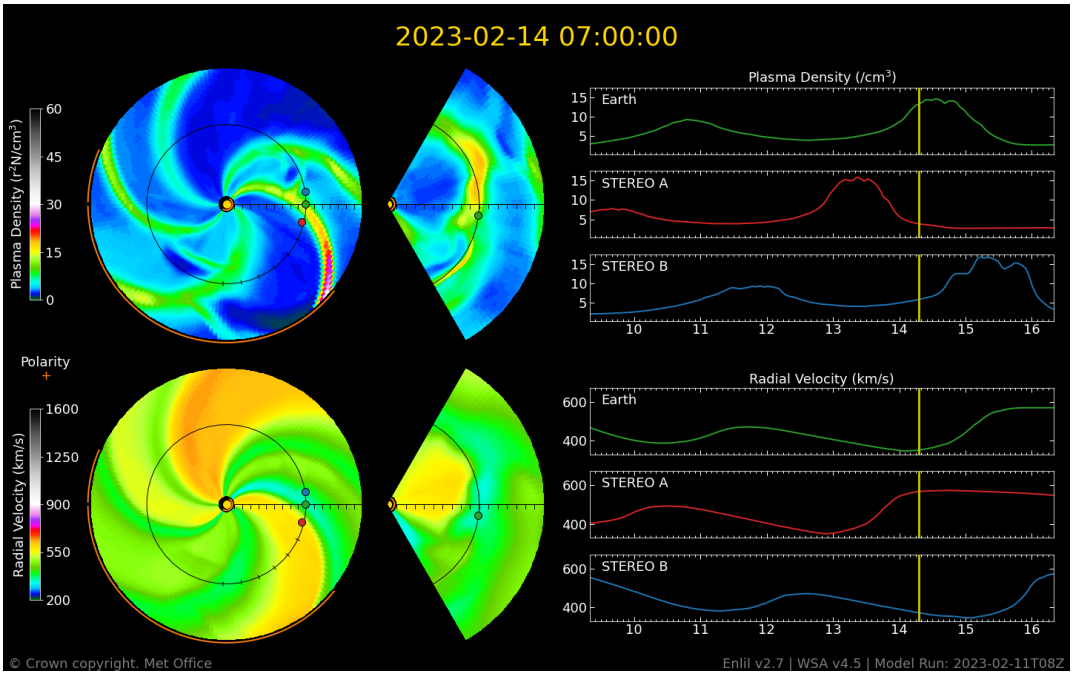
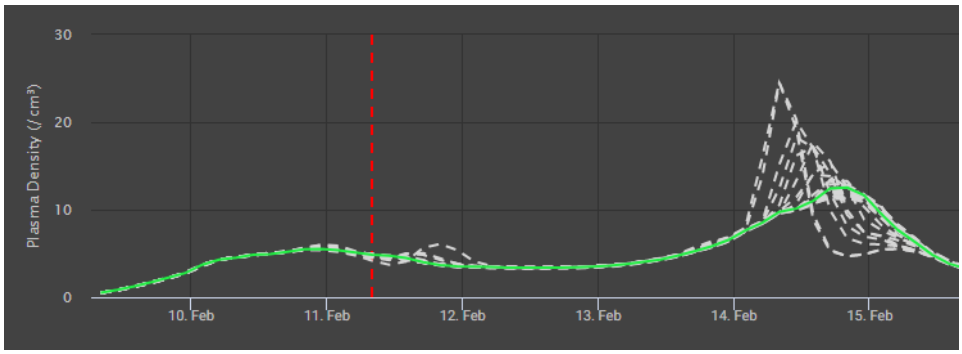
Figure 2: ENLIL and Ensemble gives a slight chance of glancing blow(s) from CMEs on the 11th and either on the 14th or 15th - although most are expected to miss the Earth.





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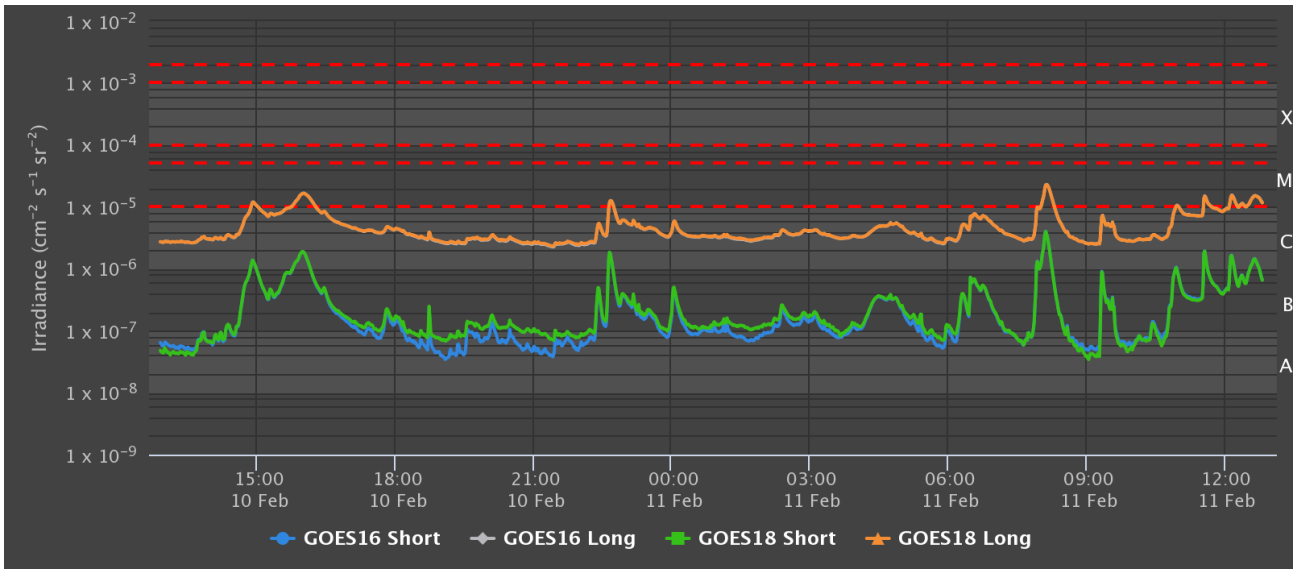
Radio Blackouts - X-Ray Flares:
Moderate activity is expected to continue through the period, with further M-flares expected, primarily from either of AR3213 Fai/Beta-Gamma in the northwest quadrant and AR3217 Ekc/Beta-Gamma-Delta in the southeast. These also bring a slight chance of X-class flares. With eleven numbered regions, and one new currently unnumbered region on the disc, isolated M-flares are also possible from elsewhere on the disc.

Surprisingly, AR3208 near the west limb, produced the largest flare recently, with an M2.3 at 11/0808 UTC. This region is due to rotate off the disc in the next 12 hours or so. However, AR3213 has been the source of multiple M-flares over the last few days, including an M6.3 on the 7th February, but is now showing some signs of simplification, losing its delta spot and reducing in penumbra extent. Conversely AR3217 has seen its penumbra extent increase, and a moderately sized, compact leader spot, which contains a delta spot. This additional complexity, along with significant magnetic looping visible in SDO imagery suggests this is the most likely source of notable flaring. The other regions on the disc are generally simpler, but still contain a risk of isolated M-flares, especially from the larger regions such as AR3214 in the northwest quadrant, or AR3220 to the southeast of AR3217.

Far-sided products also suggests the potential for further spots to rotate onto the northeast limb through the period, however this is low confidence.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	60	50
Very Active	R3 to R5 X Class	No	15	15	10	10

Figure 3: GOES-16/18 X-Ray Flux



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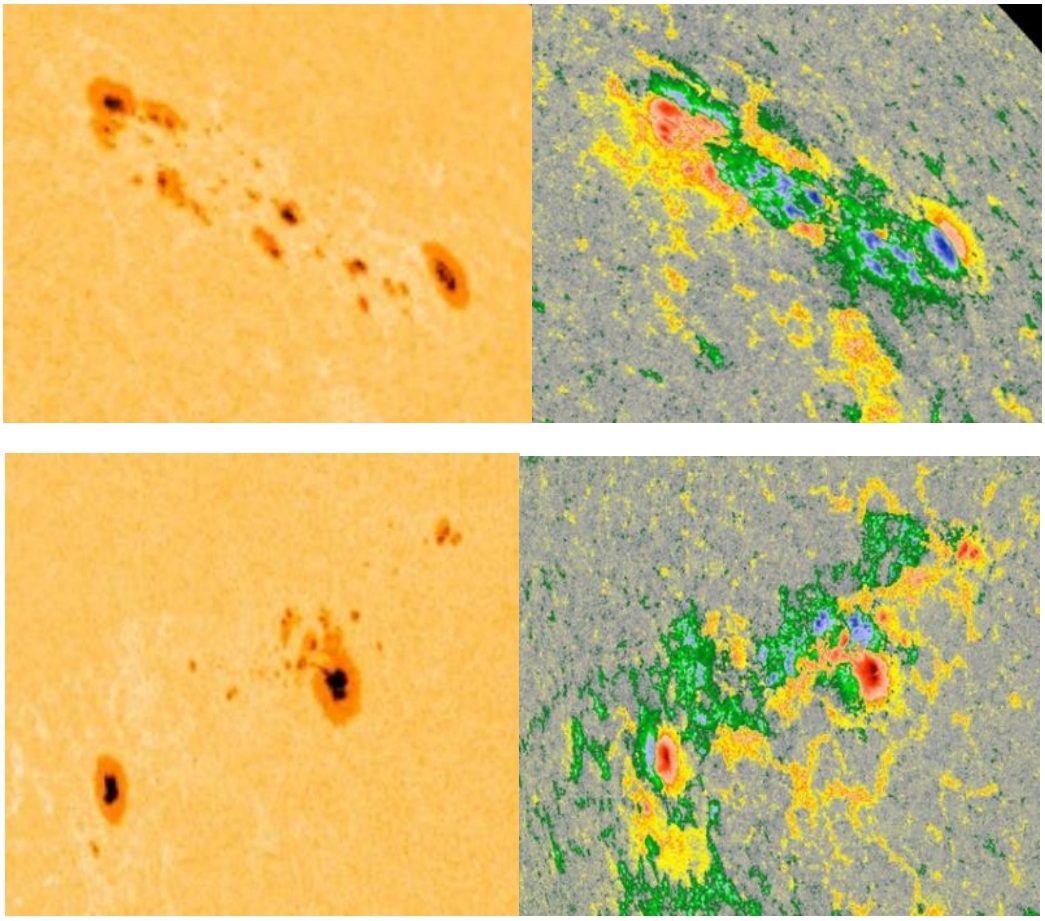
Solar Radiation Storms - (High Energy Protons):
High energy (greater than 10MeV) proton flux as observed by GOES16 is currently at background levels. No notable high energy proton response was observed from the M-class flares so far, however any further significant flares will give a chance of count rates increasing, with a slight chance of reaching the S1 level. This risk increases from day 3 (13th) onward as AR3217 moves closer to the centre disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	5	5	10	10
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 4: SDO Intensitygram and Magnetogram of AR3213 (top), and AR3220, AR3217, AR3219 (bottom)



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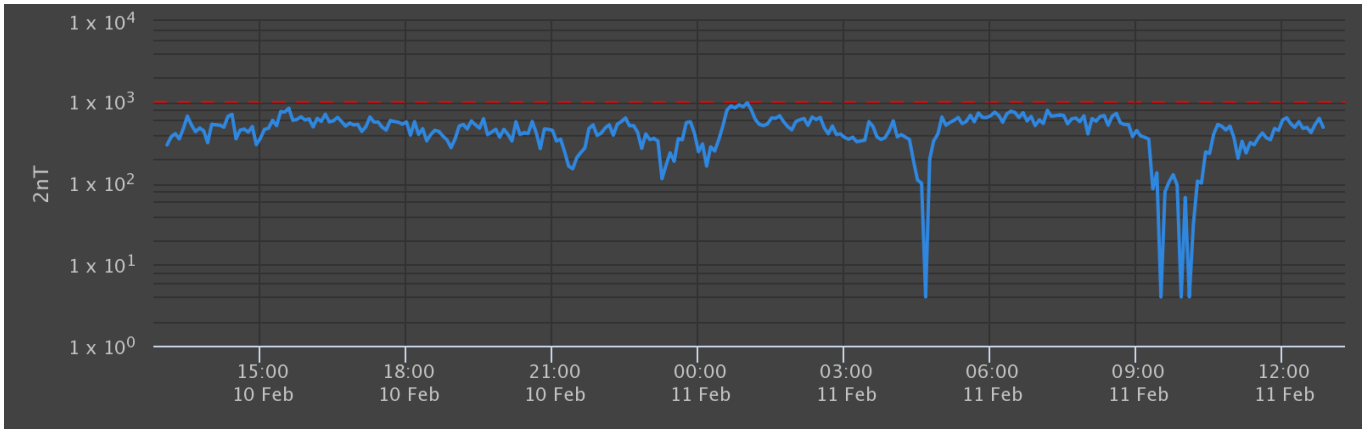
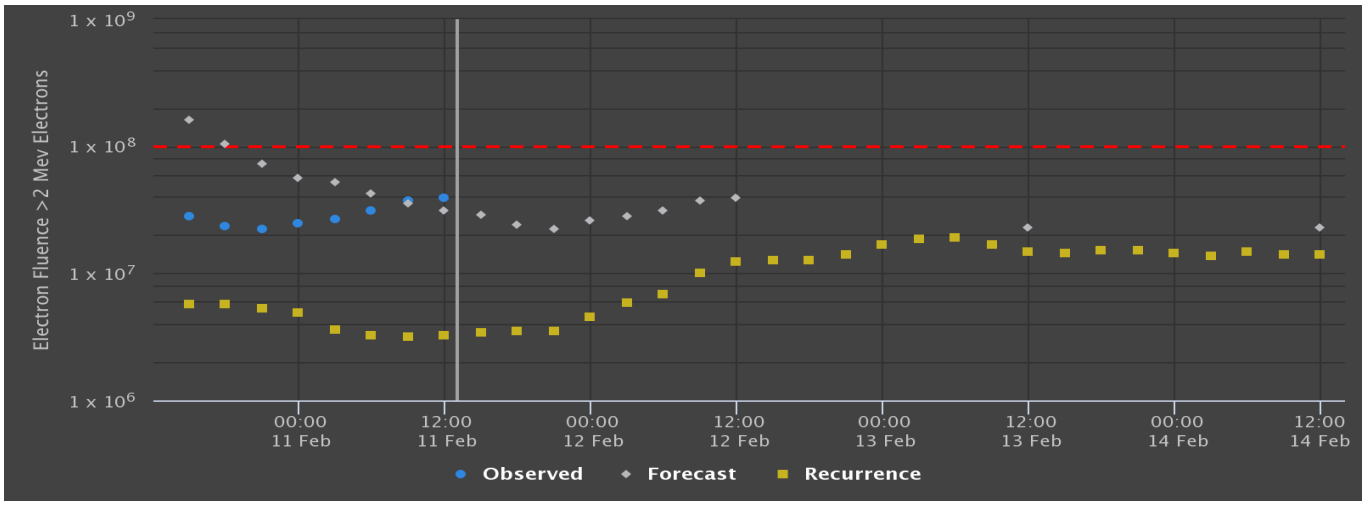
High Energy Electrons Event (≥ 2MeV):
The high energy (greater than 2 MeV) electron flux at GOES-16 is expected to continue at Background to Moderate levels with no further notable enhancement expected. Peak values are likely to gradually and erratically decline, and there is the potential to drop out to more persistent Background levels if any CME glance occurs through day 1, or day 4 (11th and 15th).

The associated 24 hour fluence is expected to remain below the Active level, despite the recent rising trend, with the recent observed value supported by REFM.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	10	10	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES-16 >2MeV Electron Flux and associated Electron Fluence with REFM.





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